

Quarterly Report – Public Page

Date of Report: *April 30, 2009*

Contract Number: *DTPH56-07-T-000009*

Prepared for: *James Merritt, DOT-PHMSA*

Project Title: *In-Situ Hydrogen Analysis in Weldments: Novel NDE for Weld Inspection*

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For quarterly period ending: *April 30, 2009*

Activities/Deliverables In Progress:

	SCH Date	CMPL Date
Task 1. Fatigue testing of hydrogen-containing linepipe steel fatigue specimens for in-situ hydrogen measurement at NIST.	4/30/2010	N/A
Task 2. Development of the hydrogen sensor for high strength steel linepipe and weldments through specific pipeline coatings in lab and in field.	10/31/2009	N/A

Technical Status

Battelle PSF Field Trip

A field trip was taken to the Pipeline Simulation Facility in West Jefferson, Ohio on March 9, 2009. Our collaborative magnetic remanence study on X65 steel line pipe previously pigged in August 2008 produced valuable data for our respective research projects.

The purpose of this field trip was to calibrate the hydrogen sensor for the effects of magnetic remanence and remanent field leakage out of an artificial surface feature (shallow drilled hole) on a pipeline without the presence of hydrogen.

Flux leakage effects of the small hole (#47 drill bit to 0.070 inch (1.78 mm) depth) drilled into the same X65 steel pipe (0.280 inch (7.11 mm) wall thickness) previously measured in August 2008 was evaluated. Fig. 1 shows the correlation of hydrogen sensor impedance data from the drilled hole with the measured leakage flux above the hole. A strong correlation between the hydrogen sensor impedance signal and leakage flux was observed near a girth weld joining two X65 steel pipes is depicted in Fig. 2. This pipe was last pigged approximately five years ago resulting in a smaller remanent field on the same order of magnitude as the section of pipe reported in Fig. 1. The spike in leakage flux is believed to be attributed to microstructural differences at the boundary between the heat affected zone and the base pipeline metal due to this 0.75 inch (19.1 mm) wide girth weld. The estimated eddy current depth of penetration for 200 Hz is 0.08 inch (1.98 mm). In future field tests, flux leakage can be used as a weld microstructure survey tool based on Fig. 2. The HAZ/BM boundary can be located by flux leakage prior to hydrogen content assessment of the weld with the hydrogen sensor. This is an important discovery that will expedite the hydrogen content assessment process.

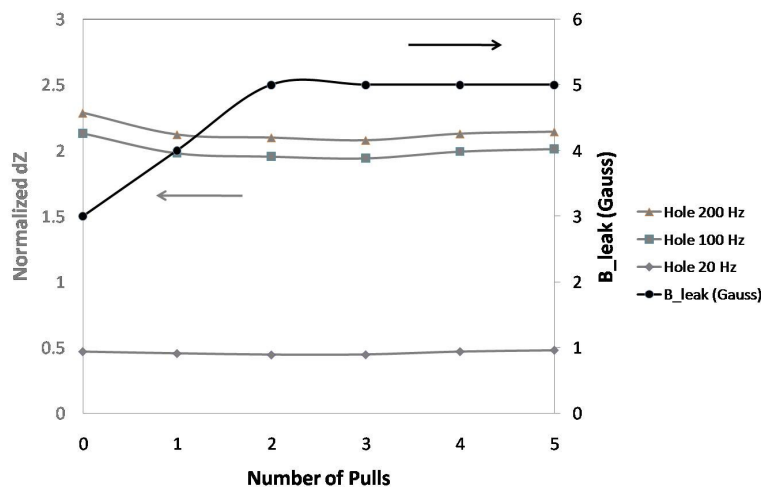


Fig. 1. Simultaneous plot of normalized impedance change of drilled hole in X65 steel pipe and detected leakage flux normal to the pipe surface above the hole for five successive pig pulls

Fig. 3 is a schematic of the flux leakage field detected in Fig. 2. The hydrogen sensor impedance signals were made through a 0.020 inch (0.51 mm) thick coating. The normalized coating impedance was measured from a piece of coating that flaked off and is 0.000164, roughly four orders of magnitude below the normalized impedance of the girth weld.

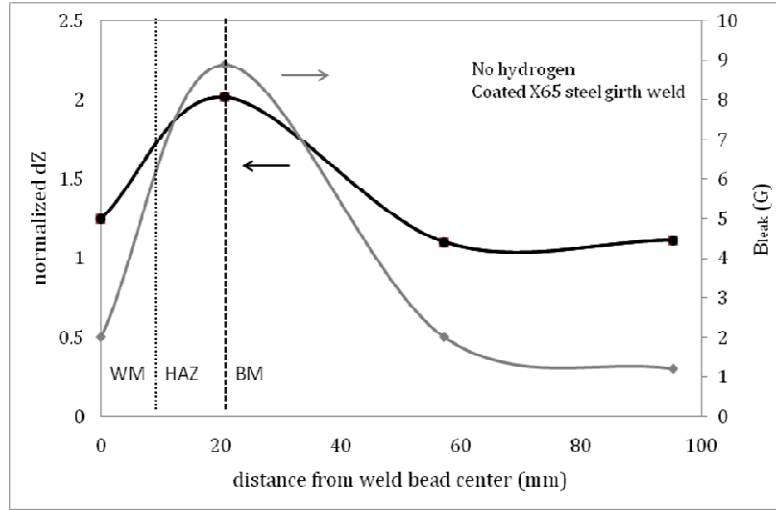


Fig. 2. Simultaneous plot of normalized impedance change at 200 Hz for an X65 steel girth weld measured through a coating and detected flux leakage transverse to the pipe as a function of distance from the centerline of the girth weld bead

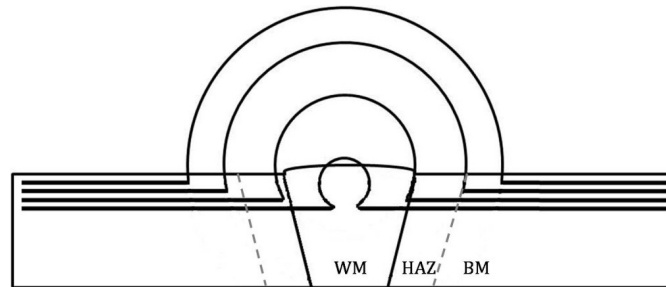


Fig. 3. Cross-section schematic of flux leakage of a girth weld bead

It was observed that the flux leakage due to a girth weld is stronger than the drilled hole. Fig. 2 conclusively shows that the microstructure associated with the girth weld can be sensed both by flux leakage and low frequency impedance. The uniformity of weld bead size, welding heat input, and other parameters of welds made in the field make this assessment of weld microstructure valuable and relevant to field measurements. In future field testing on in-service pipelines where hydrogen is present, flux leakage can be used to specify the weld HAZ region to be inspected by the hydrogen impedance sensor. Fig. 4 reports the acute impedance signal due to hydrogen content in X80 pipe steel compared with the relatively subtle impedance signal that differentiates X52, X65, and X100 steels. Based on these findings, it is predicted that the impedance signal of hydrogen content levels as low as 1.0 ppm will be much greater than the impedance signal associated with

girth weld microstructure reported in Fig. 2. This result eliminates the need for a multiple NDE tool approach to assess the various linepipe microstructures. It was previously believed that the microstructure signal would interfere with the hydrogen content signal. As can be seen in Fig. 4, the impedance signals of the various steel classes is indistinguishable but insignificant to the much stronger hydrogen content signal.

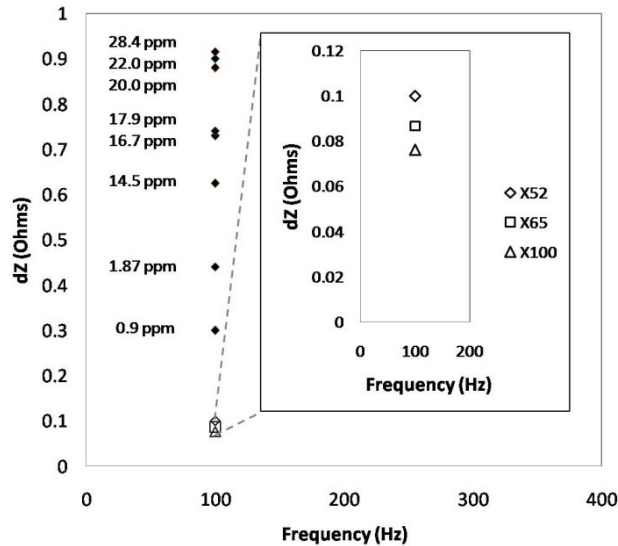


Fig. 4. Low frequency impedance as a function of hydrogen content for hydrogen charged X80 steel specimens. *Embedded figure is low frequency impedance as a function of uncharged steel microstructure (X52, X65, and X100).*

Business Status

Technical and Deliverable Milestone Schedule								
<u>Item No.</u>	<u>Task No.</u>	<u>Activity</u>	<u>Quarter No.</u>	<u>Expected Completion Date/Mos</u>	<u>Payable Milestone/Deliverable</u>	<u>Projected Federal Payment</u>	<u>Projected Partner Cost-Sharing</u>	<u>Total</u>
36	13	Development of the hydrogen sensor for high strength steel linepipe and weldments through specific pipeline coatings in lab and in field.	7 (Q6 - Q9)	27th month (Q6-Q9)	2nd Progress Report on hydrogen sensor and practice for high strength steel linepipe and weldments through specific pipeline coatings.	\$35,000	\$30,000	\$65,000

37	9	Fatigue testing of hydrogen-containing linepipe steel fatigue specimens for in-situ hydrogen measurement	7 (Q2 - Q11)	33rd month (Q11)	Quarterly progress report on fatigue testing of hydrogen-containing linepipe steel (first linepipe) fatigue specimens for in-situ hydrogen measurement	\$20,000	\$38,000	\$50,000
38	7	7th Quarterly Status Report	5	15th month (Q5)	Submit 5th quarterly report	\$2,500	\$0	2500
		Seventh Payable Milestone	7	21st month (Q7)	SUBTOTAL	\$57,500	\$68,000	\$125,500

Meeting with Edison Welding Institute Project Managers Nancy Porter, Susan Fiore, and Mark Norfolk, Jim Merritt, and Joshua Jackson, President of Generation 2 Materials Technology, LLC, (G2MT) took place on Tuesday, April 21, 2009. Interest in diffusible hydrogen assessment expressed. G2MT is the leading firm pursuing commercialization plans of the hydrogen sensor.

Meeting with Richard Hellner of Xcel Energy to obtain girth welding procedures for SMAW girth welds for natural gas pipeline steels with SMYS ranging from 42 to 70 ksi on March 19, 2009.

Meeting with an end user took place Friday, April 24, 2009. Research group issued request for welding procedures and industrial reports on girth weld microstructure. Girth weld samples for hydrogen charging requested. Coordinated several trips to the field for summer and fall 2009 and beyond.

Reporting Period: 2/01/09 to 4/30/09

Funding Source	Cost Share Budget		7 th Quarter		Cumulative to Date	
	Cash	In-Kind	Cash	In-Kind	Cash	In-Kind
NIST		402,000.00		40,000.00		237,600.00
Xcel Energy		150,000.00		15,000.00		65,400.00
TMR Exploration		150,000.00		5,000.00		85,000.00
Blade Technologies		45,000.00		-		20,000.00
Total Cost Share Contributions		747,000.00		60,000.00		408,000.00

Results and Conclusions

Fig. 2 conclusively shows that the microstructure associated with the girth weld can be sensed both by flux leakage and low frequency impedance. The uniformity of weld bead size, welding heat input, and other parameters of welds made in the field make this assessment of weld microstructure valuable and relevant to field measurements. In future

field testing on in-service pipelines where hydrogen is present, flux leakage can be used to specify the weld HAZ region to be inspected by the hydrogen impedance sensor. Fig. 4 reports the acute impedance signal due to hydrogen content in X80 pipe steel compared with the relatively subtle impedance signal that differentiates X52, X65, and X100 steels. Based on these findings, it is predicted that the impedance signal of hydrogen content levels as low as 1.0 ppm will be much greater than the impedance signal associated with girth weld microstructure reported in Fig. 2.

The conical tips of the new sensor result in an enhanced spatial resolution over the current sensor during transverse girth weld measurements. Enhanced spatial resolution is critical in differentiating weld microstructures for hydrogen content assessment. In addition, the conical core legs will dramatically increase the flux density generated by the sensor on the surface of the linepipe by reducing the footprint area of the core. The pointed core legs will also provide flexibility in coupling with various linepipe curvatures while maintaining a constant lift-off.

Issues, Problems or Challenges

There are no issues or problems this quarter. The upcoming challenges include obtaining accurate and repeatable diffusible hydrogen content measurements in welds immediately following the welding process.

Plans for Future Activity

Field Trips to Inspection Digs

Future field trips are being coordinated with a national pipeline company. There are two trips planned for June and July of this summer based on coating inspection surveys. During a recent visit, a representative of the company outlined coating thickness specifications for laboratory calibration of the sensor lift-off. Laboratory procedures are in place to calibrate the sensor for coating lift-off.

This company will be installing a new natural gas pipeline in the next year. A field trip is planned for baseline measurements on the girth welds made during installation. This will be an opportunity to calibrate the sensor prior to service and pigging. Follow-up field visits will provide calibration for subsequent service and pigging effects.

Girth Weld Guidelines

Richard Hellner of Xcel Energy has provided the welding procedures for SMAW girth welds for natural gas pipeline steels with SMYS ranging from 42 to 70 ksi. Laboratory weld specimens will be made according to these procedures for hydrogen charging calibration experiments.

Extending our Collaborative Efforts with Battelle Memorial Institute

Further testing of the correlation of flux leakage field detection with girth weld microstructure is being proposed with Bruce Nestleroth of the Battelle Memorial Institute. These include pulling MFL pigs through the two welded sections and

monitoring the effects with the new field sensor array and flux leakage detecting gaussmeter.

Sensor Calibration Through Pipeline Coatings

The thickness of pipeline coatings range from 14 to 40 mils. This includes coal tar, FBE, and 3M Scotchkote 323 liquid epoxy. A piece of 20 mil thick FBE coating will be tested in addition to 323 samples of 25 and 40 mil thicknesses.